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SYSTEM ENGINEERING REPORT

Report No. DM-008
Date 6/8/92
Prep. by MACHAK
Page 1 of 8
Alternate #

SUBJECT

MIXIMUM f/RATIO OF AFT CONFIGURATION TELESCOPE

PROJECT SOFIA

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To: Distribution
From: Dan Machak
Subject: Maximum f/ratio for aft configuration

Attached is a copy of the final version of a report studying the maximum possible f/ration of a telescope mounted in the aft cavity.

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Ames Research Center **Systems Engineering Report**	**Reviewed By:**
Subject: Maximum f/ratio of Aft Configuration Telescope	**Project:** SOFIA
Prep by: Dan Machak	**Date:** 6/8/92

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INTRODUCTION

This study was undertaken to estimate the maximum f/ratio that could be obtained by moving the telescope assembly to the aft configuration. More space is available in the aft cavity, which means that a higher f/ratio telescope could fit in the aft cavity. In this study, the largest telescope which will fit into the aft cavity is determined and the f/ratio of this telescope is calculated. The effect of changing the secondary mirror diameter is also examined. This study is preliminary due to design dependency on the actual TA and cavity configuration. Assumptions used are noted, and are felt to be relatively conservative.

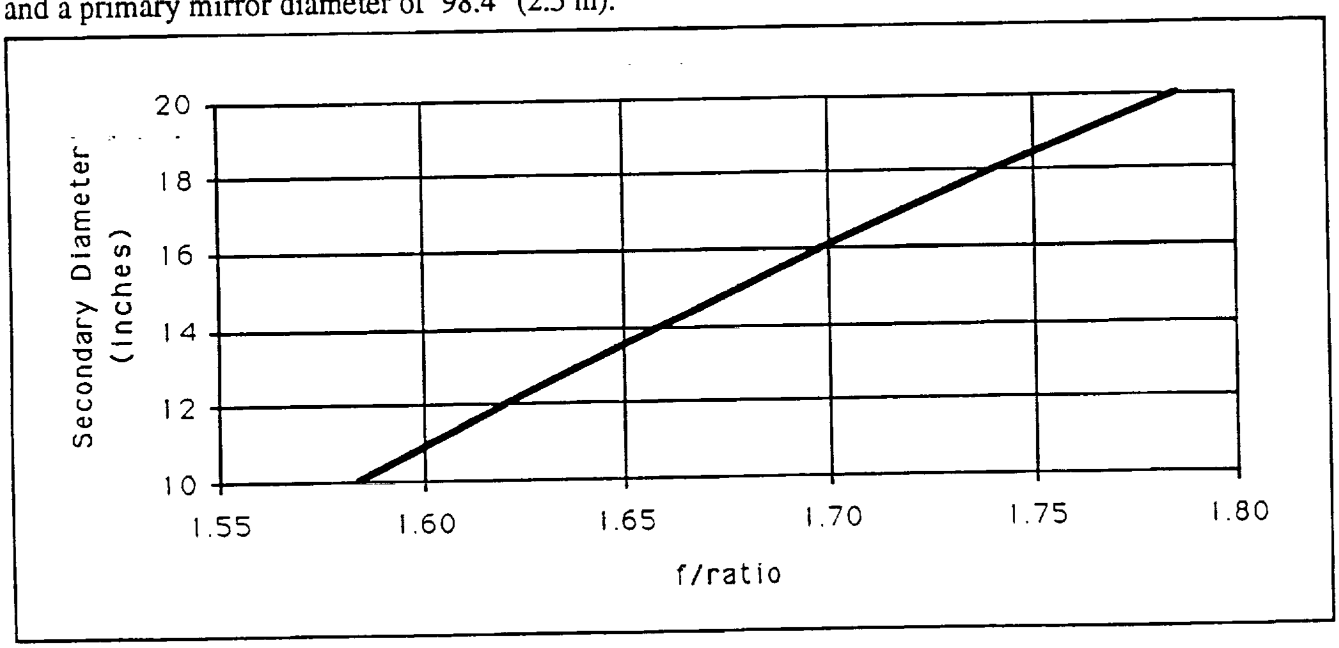
SUMMARY

The three main conclusions of this study are:

1. For a 13.8" (35 cm) diameter secondary mirror, an f/ratio of 1.65 can be obtained in the aft cavity. For the same configuration, if the diameter of the secondary mirror is increased to 19.7" (50 cm), the maximum allowable, then an f/ratio of 1.78 is obtainable.
2. A shear layer with 7.5° growth into the cavity may impose minor restrictions on the maximum f/ratio telescope beyond those caused by the assumed door configuration .
3. The maximum f/ratio achievable may be either increased or decreased through changes in the location of design parameters such as the location of the elevation axis and location of the spherical air bearing center.

RESULTS

The relationship between the diameter of the secondary mirror and the primary f/ratio is shown below. This is based on a fixed distance of 140" between the primary mirror and secondary mirror, and a primary mirror diameter of 98.4" (2.5 m).



Secondary Mirror Diameter vs. Telescope f/ratio

ASSUMPTIONS OF STUDY

A number of assumptions were made with respect to the design of the telescope and the spatial envelope available to the telescope. These are listed below.

1. The shear layer growth into the cavity is assumed to be 7.5° from the outside edge of the forward lip of the aperture door.
2. A similar door design to the forward configuration is used, that has the aft ramp moving with door aperture.
3. The aft ramp is 41" long.
4. The door aperture is 119" long with the forward lip of the aperture located 20" from the inner wall of the forward bulkhead.
5. The center of the telescope rotation axes is located at (STA 1730, BL 0, WL 231).
6. The phase B telescope design was used to determine the space needed by the centerpiece structure and the secondary mirror assembly (SMA).
7. There is no requirement for completely independent motion of the telescope and cavity door. It is assumed that the telescope will have to be caged in a particular position when the cavity aperture door is open or closed. Further study of this issue will be needed when configurations begin to solidify.

ANALYSIS

1. A rough envelope of the telescope motion was constructed using the outline of a representative telescope centerpiece and secondary mirror and ±5° off axis movement by the telescope.
2. Using this envelope a configuration was found in which both the centerpiece and the secondary mirror were just within their limiting envelopes imposed by the cavity door. The dimensions of this configuration are shown in FIGURE 1. During operation, the most restrictive part of the cavity door envelope with regards to the centerpiece structure is that part of the envelope occurring at station 1820. This is because during operation, the aperture door is in the top half of the cavity and is not in a position to interfere with the centerpiece. In FIGURE 2, a circle was drawn that corresponds to the outer most point on the centerpiece and is shown not to interfere with the door envelope. The secondary mirror is located at station 1820 and therefore must only be compared to the door envelope for that station. Again, a circle was drawn that represents the full range of motion of the telescope and the only point of interference between the secondary mirror and the cavity door is at the bottom of the cavity. Since the telescope will not be turned upside down during operating conditions, this is not a concern.
3. The f/ratio was calculated using the following formula.

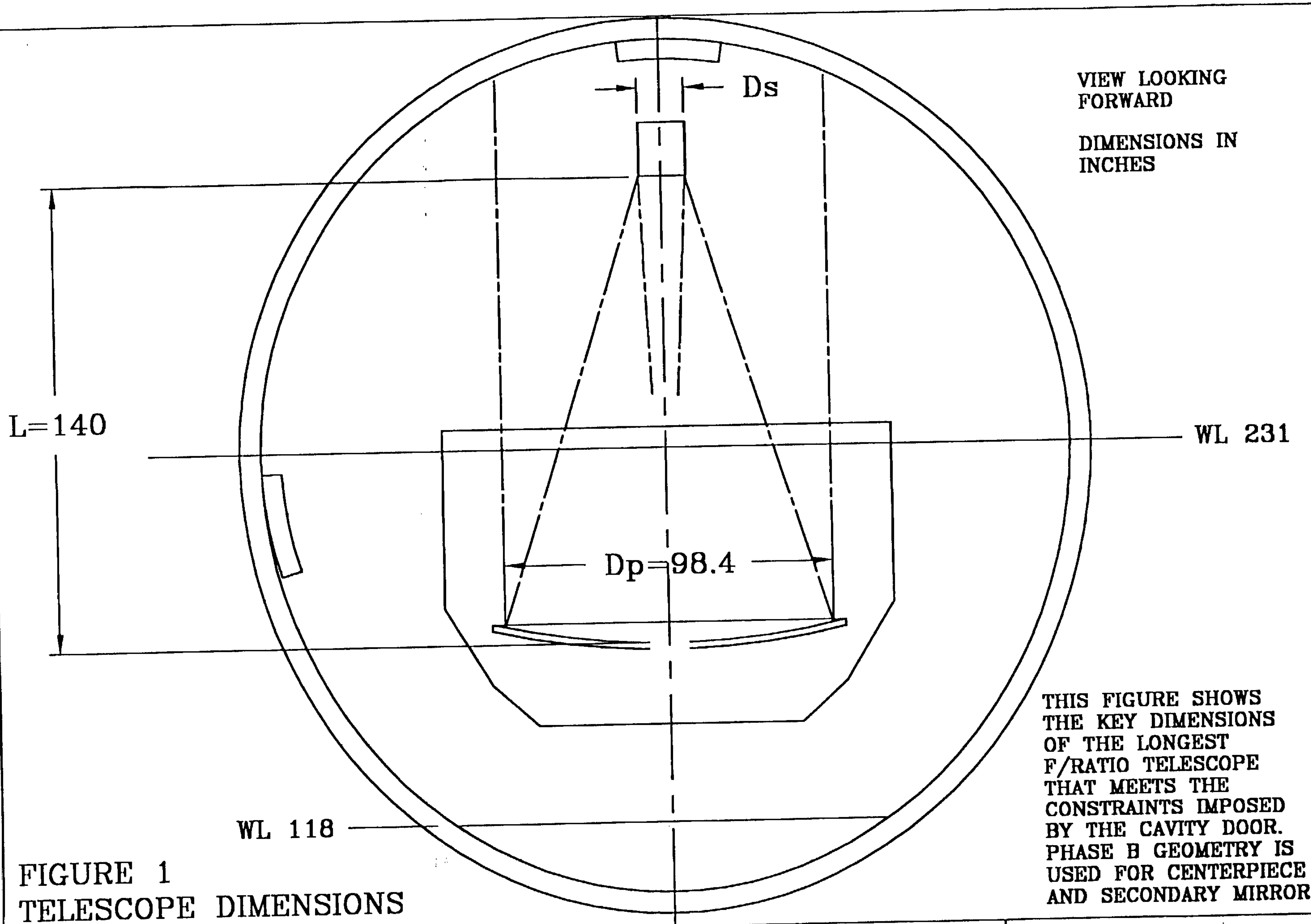
$$f/\# = \frac{L}{D_p - D_s}$$

   where D_p and D_s represent the diameters of the primary and secondary mirrors respectively, and L is the distance from the primary mirror vertex to the secondary mirror. For this study, D_p was held constant at 98.4". Using the telescope envelopes a maximum value of L was found to be 140".
4. After verifying that the ±5° physical envelope was satisfied, the shear layer operating envelope was checked. An envelope of the secondary mirror was constructed as in step 1 above, for a ±4° out of plane angle. The envelope swept out by the secondary mirror was compared to the shear layer envelope. As can be seen in FIGURE 3, between the elevation angles of 20° and 60°, there is a small impingement of the secondary mirror into the 10" shear layer buffer zone. Over the range of 15° to 70°, the impingement reaches a maximum of about 2.5".

DISCUSSION

This was a very preliminary look at determining what the maximum achievable f/ratio telescope might be for the aft cavity. There are some other considerations not taken into account here that could both increase or decrease this f/ratio estimate.

1. The f/ratio could be increased by considering other points of rotation in the cavity to maximize the distance between the primary and secondary mirrors.
2. The door design used here is conservative, which means that extra space may be available once a more detailed door design is available for the aft configuration.
3. No regard for even distribution of mass was made in this study. A center of rotation may be needed which more evenly distributes the mass about the elevation axis. This could result in the selection of an axis of rotation that would reduce the maximum achievable f/ratio.



THIS FIGURE SHOWS THE KEY DIMENSIONS OF THE LONGEST F/RATIO TELESCOPE THAT MEETS THE CONSTRAINTS IMPOSED BY THE CAVITY DOOR. PHASE B GEOMETRY IS USED FOR CENTERPIECE AND SECONDARY MIRROR.

FIGURE 1
TELESCOPE DIMENSIONS

D. MACHAK 5/18/92	AS DOOR ELEVATION RANGE:	NA	SCALE: .025"=1"
	TELESCOPE ELEVATION RANGE:	90 deg	0 40 80
	MAX. OUT OF PLANE ANGLE:	0 deg	

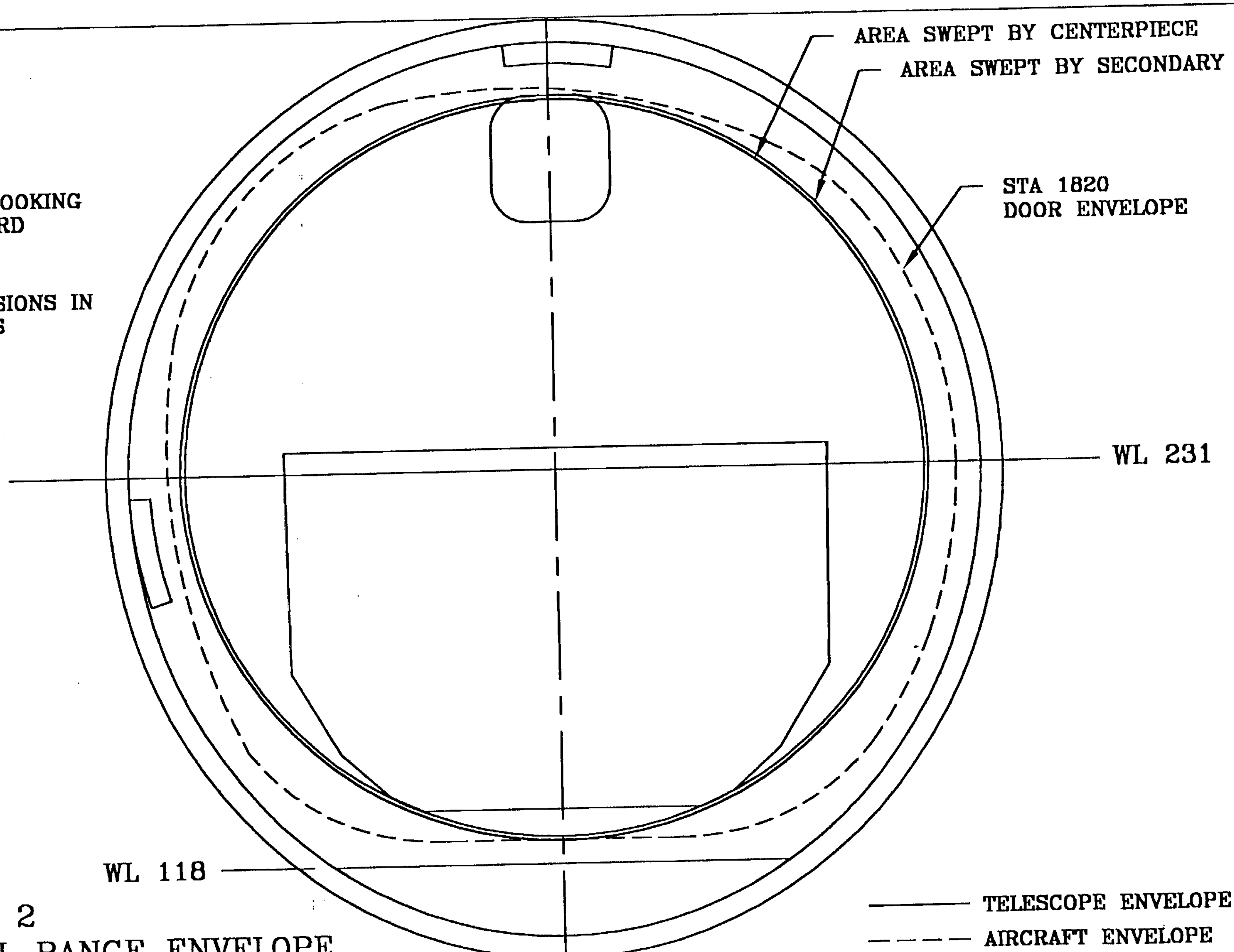


FIGURE 2
TA FULL RANGE ENVELOPE

D. MACHAK 5/18/92	AS DOOR ELEVATION RANGE:	ENTIRE 360 deg	SCALE: .025"=1" 0 40 80
	TELESCOPE ELEVATION RANGE:	90 deg	
	MAX. OUT OF PLANE ANGLE:	5 deg	

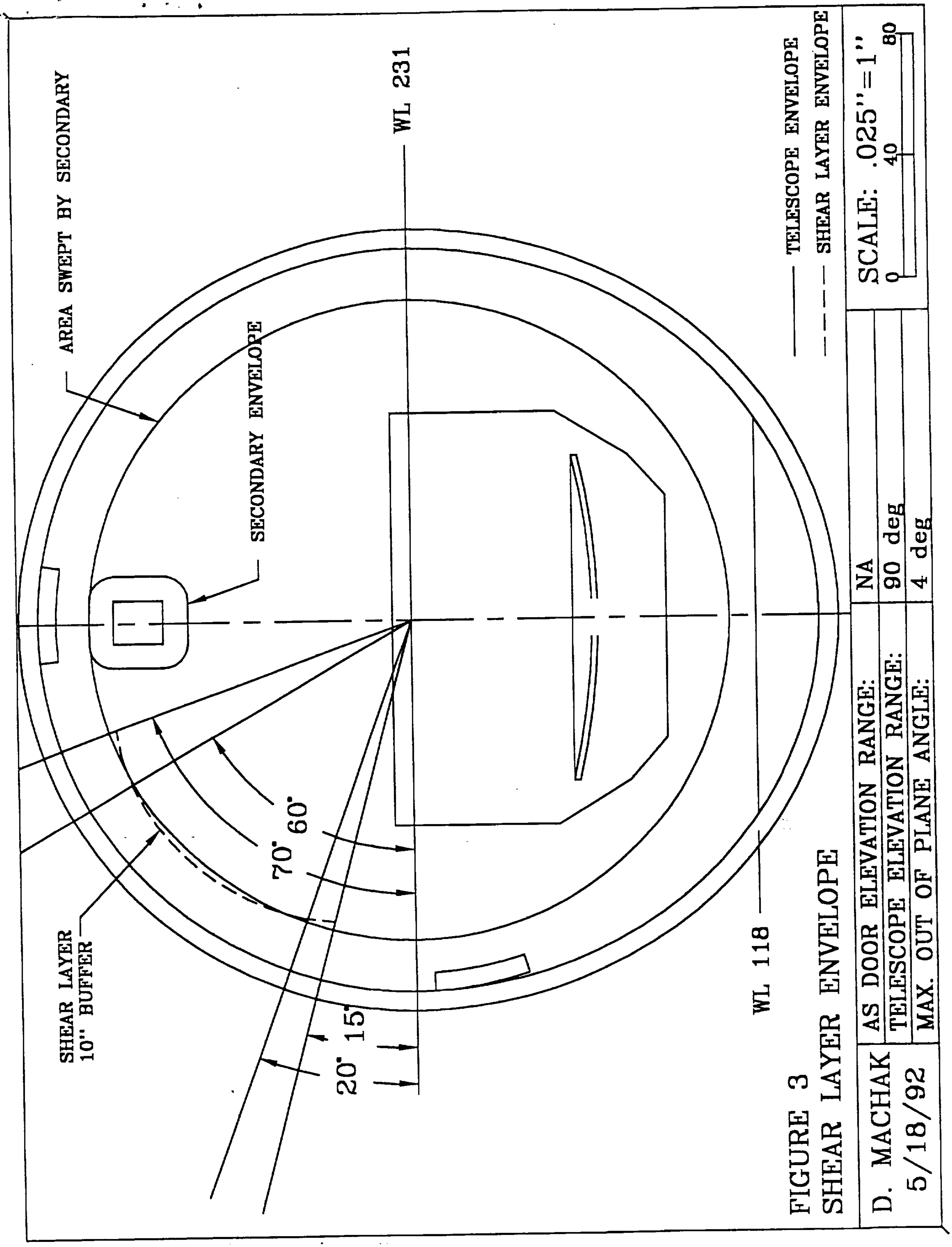


FIGURE 3
SHEAR LAYER ENVELOPE